CHAPTER 5

# ENVIRONMENTAL PRESERVATION AND ENHANCEMENT

## BASIS AND STRUCTURE

The NJMC has dual commitments to serve as trustee of the natural resources of the Meadowlands District and to foster a sustainable regional economy. The provision of space for human and wildlife needs must be a component of any comprehensive plan for the District. This chapter inventories the open space and recreational resources in the District. It examines the need for additional lands and facilities and assesses land and water resources for potential recreation and open space facilities.

When the Commission was established in 1969, the impacts of development on the ecosystem were immediately evident. Uncontrolled pollution from industries and minimal treatment, if any, of wastewater were leading to the demise of many species, particularly fish, waterfowl, and the small mammals that had at one time been abundant in the Meadowlands. This unique coastal ecosystem had been written off as a biological wasteland and a regional eyesore. It was necessary for the Commission to establish a means of analyzing the environmental conditions of the District and develop short and long term measures for reviving and protecting the ecosystem.

The Commission has responded in several ways. Through Intermunicipal Tax Sharing, the NJMC has been able to protect the existing ratable values of each of the Meadowlands towns when the NJMC was created, while calling for the equitable sharing of new financial benefits and new costs resulting from the development of the Meadowlands District as a whole from that time forward. In brief, the mechanism for tax sharing is a common pool, the Intermunicipal Account. Standards are prescribed under which the municipalities contribute or draw from the pool. Tax sharing has allowed the Commission to master plan the District as a region without consideration of municipal boundary lines. In doing so, the Commission was able to promulgate a plan to protect larger expanses of marshland and sensitive environmental habitats. In more recent years this concept has been implemented with the purchase of sensitive lands and valuable wetland habitats as the Commission has been able to secure appropriate funding. Tax sharing is discussed more fully in Chapter 8, Economic Vitality.

In April 1998, the NJMC entered into an agreement with Rutgers Center for Information Management, Integration and Connectivity (CIMIC) for the creation of the Meadowlands Environmental Research Institute (MERI). MERI functions as a world-class center for sci-

entific investigation of urban wetlands, their functioning, restoration, and sustainable management, with emphasis on coastal wetlands. MERI integrates activities that preserve, restore and enhance the environmental quality of the Meadowlands through a comprehensive environmental monitoring system which benchmarks and targets environmental improvements. The establishment of MERI will result in significant contributions to the region through shared and stored data, as well as providing instructional and research opportunities to multidisciplinary faculties and personnel at collaborating institutions.

In spite of the NJMC's efforts to address many of the area's environmental concerns, varying degrees of problems associated with air and water pollution, flooding, diminished wildlife habitat, unclosed landfills and the like still exist today. Consequently, a clear understanding of the District's natural environment and its proper management is essential to this Master Plan. This chapter is of particular value in relationship to the chapters concerning Land Use, Housing, and Economic Vitality, as the finite, natural environment is a primary determinant of the types, locations, and intensities of permitted development.

## HISTORIC AND EXISTING ENVIRONMENTAL CONDITIONS

### Climate

The climate of the Meadowlands is mainly determined by both the topography of the area and its geographic location of approximately 40° N latitude and 74° W longitude. Although the area is close to the Atlantic Ocean, the climate is considered more continental than maritime. This is due to the dominant airflow pattern, which brings air masses over the continent in an easterly direction.

During the winter months, a polar continental air mass originating in Canada dominates the area, while the summer months are dominated by a maritime tropical air mass from the Caribbean and the Gulf of Mexico. These seasonal air masses account for the mean annual temperature range of approximately 31° F as the low and 77° F as the high. The movement and interaction of these air masses are also responsible for annual precipitation of approximately 45 inches.

As cited by the NJDEP, the international scientific community has given considerable attention to the issue of global climate warming in the last century. The consensus is that emissions of greenhouse gasses (GHGs) are a major cause of worldwide climate change. GHGs absorb infrared energy in the form of heat, preventing it from escaping into space. Without a certain level of GHGs in the atmosphere, the earth would be cold and devoid of life as we know it. Nevertheless, the trend is for warming due to GHGs.

Beginning with the Industrial Revolution, humans began to alter the environment through new agricultural and industrial practices. The factors of population growth, burning fossil fuels, and deforestation have affected the mixture of gases in the atmosphere. With an increase in the concentration of GHGs, more heat is trapped and the average global temperature rises. The oceans expand, and water levels rise.

The Meadowlands District is both a contributor to and a recipient of the consequences of climate change. The District is located within a major urban area, heavily industrialized and densely populated. Also, the tidal range for wetlands within the District is about 3.9 feet (per the US Geologic Service's National Geodetic Vertical Datum of 1929). Higher sea levels mean an increase in flooding severity and more frequent and intense tropical storms. Tropical storms developing over the Atlantic Ocean, the Caribbean Sea and the Gulf of Mexico can impact the US coastline, occasionally including the Meadowlands District. Tropical storms produce high winds and torrential rains. High winds can destroy poorly constructed buildings, such as mobile homes and cause considerable disruption through extensive damage to trees, water and underground utility lines (from uprooted trees), and fallen poles. Heavy rain causes floods. Hurricane Floyd brought heavy rains and record flooding to the area in 1999.

## Geology

The Meadowlands is located within the Piedmont physiographic province, which encompasses the northern part of New Jersey. The topographic relief of the Piedmont is generally characterized by wide valleys and gently rounded hills lying at elevations that vary from 100 to 400 feet above sea level. The underlying bedrock geology in the Meadowlands consists mainly of sedimentary deposits, such as sandstone and shale. These deposits, collectively known as the Newark Group, are of the Triassic age and form low ridges and valleys that trend northeast to southwest, essentially parallel to the Palisades Ridge and the First Watchung Mountain.

The Newark group is divided into three formations: the Stockton, the Lockatong, and the Passaic (formerly known as the Brunswick), composing the lower, middle and upper units, respectively, of the Newark Group. The Passaic formation is the predominant layer in the Meadowlands, forming most of the bedrock of the Hackensack River basin. It is composed of sandstone, mudstone, siltstone and conglomerate containing gypsum and glauberite. The Stockton formation occurs in a narrow belt extending from the town of West New York, New Jersey northward to Rockland County, New York. It is composed of shale, red sandstone, light colored sandstone, and mainly quartz and feldspar. The Lockatong formation interweaves with both the Stockton and Passaic formations, but generally lies between the two. It is composed of mudstone of chemical and detrital origin and contains sodium feldspar, calcite, chlorite, dolomite, albite and analcime. The depth of the bedrock valleys ranges from 55 feet below sea level at the Sparkill Gap, to more than 250 feet below sea level around Newark. The Piedmont has been widely affected by Pleistocene glaciation, which formed the Passaic and Hackensack River drainages.

The formation of the Meadowlands was the result of the last major glacial advance, the Wisconsin, which built the massive Harbor Hill terminal moraine that extended from Long Island west across Staten Island to Perth Amboy. Between 15,000 and 12,000 years ago, this terminal moraine served as a dam for glacial meltwaters, and formed the southern boundary for Glacial Lake Hackensack. Sedimentation resulting from the advance and retreats of Pleistocene ice fronts resulted in the deposition of massive beds of lacustrine clays and glacial till which now fills the bedrock valleys and mantles the sandstone ridges. Following the drainage of Glacial Lake Hackensack (approximately 10,000 years ago), the lake bottom went through a complex

succession of hydrologic and vegetation regimes before achieving its modern condition. With the gradual post-Pleistocene sea level rise, the initial freshwater marsh was gradually invaded by increasing amounts of seawater and consequent tidal influence. Much of the Meadowlands is at or just above sea level.

## Soils

Soils within the District fall within two broad categories: urban land and tidal marshes. Urban land is a miscellaneous soil type in which the origins and characteristics used to determine naturally occurring soil types are unidentifiable. It reflects areas in which some form of development, such as buildings, roads, landfills, or other dredge-and-fill activities, has occurred. The Udorthents and urban land soils elsewhere are there as a result of past dredge-and-fill activities. This category is described by the Udorthent (U) series.

Tidal marshes consist of areas where development has not taken place, such as open water and wetlands. Approximately half of the District's soils are tidal marsh soils composed of fine silts and clays high in organic content. Exceptions to this are the diabase rock outcroppings of Laurel Hill (also known as Snake Hill) and Little Snake Hill in Secaucus.

The wetlands within the District are the remnants of a once continuous marsh that extended from the area of Elizabeth and Newark northward beyond Overpeck Creek. Tidal marsh soils consist mainly of decaying vegetative matter, creating an organic soil that is "spongy" in nature. These soils are generally inundated by tidal action twice a day and, as a result, the anaerobic microorganisms involved in the process of decomposition are hindered by the saturated conditions. This produces a soil which is an accumulation of partially decayed organic matter, referred to as peat. Of the three types of peat (woody, fibrous, and sedimentary), fibrous peat is the dominant type found within the District. This peat is categorized by its high fiber content which results from the partially decayed vegetation. The fibrous peat increases in thickness towards the center (Hackensack River) of the District.

Because of the extensive marsh soils and the amount of disturbance related to urban land soils, many structures in the Meadowlands require pile-supported foundations.

## Topography

The Meadowlands are situated in a valley or "bowl" with ridges on either side that run parallel to one another in a northeast to southwest direction, reaching more than 100 feet above mean sea level (MSL). Secaucus contains a ridge that is 60 feet above MSL with gently sloping sides located parallel to County Avenue. Other prominent natural elevations within the Meadowlands include Laurel Hill (Snake Hill), which rises approximately 170 feet above MSL and Little Snake Hill reaching a height of 73 feet above MSL.

## Hydrology

***Surface Water***

A central feature of the Meadowlands is the Hackensack River, which begins in Rockland County, New York. The 50-mile southward course of the River parallels that of the nearby Hudson River to the east. The River eventually flows into the Newark Bay at Kearny Point. It drains the Hackensack River watershed, approximately 34 miles in length with a width of four to seven miles. This watershed is approximately 197 square miles, two-thirds of which is located in Bergen and Hudson counties.

The Oradell Dam was constructed to supply potable water to northern New Jersey and has essentially separated the Hackensack River into two distinct components: the Upper River (above the Dam) and the Lower River. The Upper River is a controlled freshwater section in which the flow is inhibited. Water from 113 square miles of the total watershed area is impounded. This impoundment retains 84 percent of the watershed's supply in four large reservoirs. The Lower River (below the Dam) and its tributaries are bordered by approximately 8,500 acres of tidal marsh. This area is a brackish estuary that is influenced by the semi-diurnal tides. The majority of the River's lower reaches are located in the Meadowlands District.

In the Meadowlands, the major inputs of freshwater to the Hackensack River come from industrial and municipal discharges, stormwater runoff, and water spilling over the Oradell Dam. Within the District, the River is 11.5 miles in length and drains over 90% of the 30.4 square miles of Meadowlands District jurisdiction. Figure 5.1 lists the major tributaries of the Hackensack River. The River and its tributaries, along with the lower Passaic River (located along a portion of the District’s southwestern border), form several sub-watersheds. The District’s waterways and sub-watershed areas are presented in Map 5.

The Hackensack River and its tributaries have been altered at different times to meet specific needs. The lower section of the River has historically been dredged to handle barge traffic. The US Army Corps of Engineers (USACE) maintains a shipping channel at an average depth of twelve feet. Additionally, ditches and canals have been dug to control the flow of water into the tidal marshes.

Surface water features of the District are characterized by the many streams, creeks and smaller channels and ditches that drain the area. The quantity and quality of surface water in the Meadowlands is influenced by such factors as tidal flow, precipitation, permitted discharges and the release or detainment of freshwater from the Oradell reservoir. Tidal flow in the Meadowlands is such that the system is never completely flushed. By the time the tide in the upper reaches begins to recede, the next incoming tide has begun to enter the lower reaches. In a typical estuary, the freshwater flow maintains a net seaward movement of water mass and any pollutant load. The Hackensack River, however, has a disturbed flow regime; it acts as a trough in which the tidal waters slosh back and forth, only slowly getting flushed to the sea.

**FIGURE 5.1**
**Hackensack River and Its Tributaries, Meadowlands District**

| STREAM | WATER CONTROL METHOD |
|---|---|
| Hackensack River | Dam |
| Penhorn Creek | Tide gate/RR embankment |
| Losen Slote | Tide gate |
| Anderson Creek | Open to the tides |
| Sawmill Creek | Open to the tides |
| Kingsland Creek | Tide gate |
| Berry's Creek Canal | Open to the tides |
| Bashes Creek | Tide gate |
| Moonachie Creek | Two tide gates/culverts |
| Mill Creek | Open to the tides |
| Cromakill Creek | Open to the tides |
| Bellman's Creek | Open to the tides |
| Overpeck Creek | Dam/tide gate |
| Berry's Creek | Open to the tides |
| Peach Island Creek | Tide gate |
| West Riser Ditch | Tide gate |
| East Riser Ditch | Tide gate |

*Source: Draft Environmental Impact Statement for the Special Area Management Plan, June 1995*

***Floodplains***

Floodplains are those areas subject to inundation by tidal action or severe storm events at a given frequency. Within the District, special flood hazard areas inundated by the 100-year flood are characterized as indicated in Figure 5.2. Due to the prevalence of low elevations, a majority of the District is located within one of the zones. Map 6 shows the general location of flood hazard areas.

**FIGURE 5.2**
**FEMA Floodplain Zones in the Meadowlands District**

| ZONE | CHARACTERISTICS |
|---|---|
| **AE** | Base flood elevations determined and are located in elevations between 5 and 10 feet above the Mean Sea Level (floodway areas). |
| **X** | Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile and areas protected by levees from 100-year flood. |

Source: *FEMA maps for Meadowlands District—September 20, 1995.*

***Groundwater***

In aquifers underlying the District, movement and storage of groundwater occur primarily in the network of interconnected openings formed along joints, fractures and solution channels of the Passaic Formation (formerly known as the Brunswick Formation). Groundwater location varies from site to site depending on the development of joint openings and their alignment. The size and number of these openings decrease as the depth below ground surface increases. As some beds within the formation contain more openings than others, the groundwater system consists of a series of alternating tabular aquifers, permeable formations and aquicludes (impermeable strata). These rock series are several tens of feet thick and dip to the northwest at an angle of approximately 10 degrees. The water bearing fractures in each aquifer are more or less continuous, but have a poor hydraulic connection between them. These tabular aquifers generally extend downward for a few hundred feet and are continuous along the strike for thousands of feet.

Estimates of the thickness of the groundwater producing zone in the Passaic Formation have been tempered by the observation that, when a well has not found a water-bearing zone in the first 400 feet of drilling, water is unlikely to be found by drilling deeper. The zone in the Passaic Formation containing joints and fractures that are capable of storing and transmitting fresh water has been variously estimated at between 200 and 600 feet thick.

The zone of fresh (non-saline) groundwater in the Hackensack River basin appears to be thinner than 200 feet and is generally located at 400 to 500 foot depths. Typical water bearing zones in the Passaic Formation range from 200 to 600 feet deep. Glacial scour, which reaches depths of thirty feet along the western edge of the Meadowlands, has removed some of the water-bearing capacity of the Passaic Formation locally.

Other geologic formations underlying the District include the Stockton Formation, diabase intrusions (e.g., Laurel Hill), and various unconsolidated till, silt, clay and fill. The Stockton Formation is too deep under the Meadowlands to yield a significant amount of water. Diabase, with its impermeable properties, also yields small quantities and is not an important source of groundwater. Overlying the Passaic Formation are unconsolidated deposits consisting mostly of till, varied silt and clay. These materials are generally of low permeability and thus yield

limited amounts of water. The limited areas of sand and gravel deposits in the District are a small but valuable source of groundwater.

Well drilling in the Meadowlands is limited by the above constraints and yields only small to moderate supplies of groundwater. The District is primarily in a groundwater discharge area (Groundwater is generally discharging to the Hackensack River and the Atlantic Ocean.). In discharge areas, groundwater travels for longer periods and greater distances, is higher in dissolved solids, and tends to be in chemical equilibrium with adjacent rocks. In the Meadowlands, the groundwater in the Passaic Formation is highly mineralized. Chemical quality is affected by induced recharge of poor quality surface water from the Hackensack River and Newark Bay.

The Oradell Dam has effectively cut off the headwaters and source of the Hackensack River from its lower reaches, limiting the fresh water in the lower reaches. Weakened flow rate in the lower valley has exposed the groundwater system to salt water intrusions from Newark Bay. Dredging of canals has further exposed permeable materials, which can lead to additional leaching of brackish river water into the groundwater.

Within the lower Hackensack River basin, yield variation and specific capacities of wells tapping the Passaic Formation are dependent on lithology penetration and position of the wells within the groundwater flow system. The most productive areas are located in narrow belts along the east and west edges of the District, at a point mid-way between the divides of the basin and the trough. The wells in the central portion of the Meadowlands only have an average specific capacity of one gallon per minute (gpm) per foot of drawdown. The groundwater supply along the edges of the District benefits from the pressure of hydraulic connection to the Passaic Formation, a gentle gradient, and permeable unconsolidated deposits. The central portion of the Meadowlands is overlain by former glacial lake beds with poor permeability.

Data on wells tapping the Passaic Formation in Bergen County show that in general, industrial and municipal supply well yields are ten times as great as domestic well yields. Industrial and municipal supply wells are at least twice as deep and have twice the specific capacity of domestic wells. The median industrial or municipal supply well is 260 feet deep, yields 100 gpm, and has a specific capacity of 1.5 gpm per foot of drawdown. The median domestic well is 120 feet deep, yields about 10 gpm, and has a specific capacity of about 0.7 gpm per foot of drawdown.

Pollution from local industry, sewage and urban runoff prevents wellhead groundwater recharge and reduces water quality. In addition to the summer brackish flow from Newark Bay, it is believed that highly influential hydraulic subsurface connections exist between the Passaic Formation and Newark Bay. As a consequence of heavy pumping, high chloride water has been induced deep into the aquifer along the strike of the beds.

## Water Quality

The Meadowlands District lies within the basin of the lower Hackensack River. Water quality in this region has been influenced significantly by urbanization and industrialization. Due to its limited freshwater inflow and indirect link with the open sea, the lower Hackensack River is not as well flushed as other estuaries. Consequently, the District's water quality is inherently susceptible to pollutants introduced into the watershed. There are many existing point and non-point sources of pollution, which affect the present water quality. Point source pollution tends to come from activities such as sewage treatment plants and industrial discharges. Non-point sources of pollution cannot be pinpointed to the initial discharging source and include storm sewers, landfills, leachate, and surface runoff.

An analysis of data collected in the District by the NJMC defines the status of the Hackensack River. Surface water samples are collected seasonally from fourteen sites in the District, including five sites along the Hackensack River. Samples have been analyzed for the levels of dissolved oxygen, pH, temperature, and salinity; the presence of heavy metals, including cadmium, chromium, copper, iron, lead, nickel, and zinc; nutrients; suspended solids, and bacteria.

The level of dissolved oxygen is particularly critical, as it is necessary to support the maintenance, migration and propagation of the natural and established biota. Concentrations have varied widely among seasons and from year to year. For example, the restriction of freshwater input during times of drought produces worsening conditions. Dissolved oxygen readings were above the criteria minimum (standard) for 95 percent of readings in 2002 and 67 percent of readings in 2001.

Counts of fecal coliform bacteria, indicators of untreated sanitary wastes, were highly variable with time and from site to site. Bacterial counts have not exceeded the criteria maximum since fall 1998, although they are still high in some areas. Counts did show an overall reduction in concentration.

Heavy metal concentrations, by-products of industrial processes, power generation and the transportation arteries that criss-cross the District, are well below criteria limits. In recent years, drought conditions have, however, led to increased metal concentrations.

The New Jersey Administrative Code (N.J.A.C.) Section 7:9-4 defines standards for surface water quality, including the criteria required to meet these standards. The NJDEP has classified different reaches of the Hackensack River according to the surface water quality standards. The classifications are summarized in Figure 5.3.

## FIGURE 5.3
**Hackensack River Network Surface Water Classification, Meadowlands District**

| RIVER SEGMENT | CLASSIFICATION |
|---|---|
| Overpeck Creek to Routes 1 & 9 Bridge | SE2 |
| Tributaries joining the main stem down stream of Overpeck Creek | FW2-NT/SE2 |

**CLASSIFICATION TERMS:**

SE = the general surface water classification applied to saline waters of estuaries.

SE2 = SE waters that are designated for these uses: maintenance, migration, and propagation of the natural and established biota; migration of diadromous fish; maintenance of wildlife; secondary contact recreation; and any other reasonable uses.

FW = the general surface water classification applied to fresh waters.

FW1 = those fresh waters that are to be maintained in their natural state of quality (set aside for posterity) and not subjected to any man-made wastewater discharges or increases in runoff from anthropogenic activities.

FW2 = the general surface water classification applied to those fresh waters that are not designated as FW1 or Pinelands Waters.

NT = nontrout waters.

*Source: Surface Water Quality Standards, N.J.A.C. 7:9B*

**FIGURES 5.4, 5.5, AND 5.6**
*These photos give various perspectives on the District's waterways.*

**FIGURE 5.4 (above)** *An aerial view of Mill Creek and the Hackensack River looking northwest, taken by helicopter before NJMC mitigation activities.. The New Jersey Turnpike appears in the background.*

**FIGURE 5.5 (upper left)** *A boater's view of Berry's Creek in Carlstadt. The creek banks are lined with dense stands of the common reed (Phragmites australis), an invasive species. Although its origin is unclear, the common reed can be found all over Europe, Asia, Africa, North America, and Australia. Recent research involving archaeological evidence supports that both native and introduced genotypes exist in North America.*

**FIGURE 5.6 (lower left)** *A common site in the District, great egrets (Casmerodius albus) are joined by a great blue heron (Ardea herodias) at the water's edge.*

## Ecosystems and Habitats

Along with its waterways, the Meadowlands includes extensive wetlands, terrestrial ecosystems, and remnant and unique habitats. Each contributes to the biodiversity of the Meadowlands. Several features of the Meadowlands contribute to its value for wildlife. These features, as reported by Hudsonia Ltd. (Hackensack Meadowlands, New Jersey, Biodiversity: A Review and Synthesis, prepared for the Hackensack Meadowlands Partnership in August 2002), are as follows:

1. A large complex of undeveloped habitats in a vast urban-industrial area;
2. Abundant surface waters with diverse hydrology (tidal and nontidal, fresh and brackish);
3. A variety of habitats ranging from open estuarine waters to dry fill and rock;
4. Extensive areas of marsh, wet meadow, and upland meadow habitat with minimal direct human intrusion;
5. Dense stands of common reed and other plant communities that have low visibility and low penetrability (i.e., they are hard to see into and move through), and provide concealment and shelter for animals nesting, roosting, or foraging within the reed stands or on other habitats surrounded by reed stands;
6. Abundance of certain foods (including common reed for muskrats; small rodents and small birds for raptors; terrestrial insects and spiders, as well as adult chironomid midges, for small birds; macrobenthic invertebrates for dabbling ducks, gulls, terns, etc.; and fiddler crabs for turtles, herons, etc.);
7. Reduced levels of hunting, trapping, and fishing activities that might potentially affect non-target species and prey species as well as legally harvested species; and
8. Possibly reduced levels of predation, competition, and herbivory (e.g., deer grazing) providing ecological “refuge” for certain animals.

The extent to which animals can benefit from the presence of common reed or phragmites can be debated, however, the report establishes the overall value of the Meadowlands as wildlife habitat.

The report also cites several negative features that impact animal species to varying degrees:

1. Intensive replacement of “natural” habitats by altered or artificial habitats;
2. Loss of connectivity with other wetland and grassland habitat complexes;
3. Loss of sensitive species that may have served as food, symbionts, habitat structure, etc.;
4. Physical hazards of motor vehicles, aircraft, buildings, radio towers, and construction equipment;
5. High anthropogenic noise and light levels;
6. Urban-type water, soil, and air quality;
7. Contamination by metals and other toxic substances; and
8. Competition or predation from a few common, urban-tolerant animals (e.g., Norway rat, raccoon).

The presence of dense strands of phragmites is a symptom of a system degraded by unnatural forces.

A variety of invertebrates, amphibians, reptiles, fish, birds and mammals are found in the Meadowlands. The NJMC collected 53 species of invertebrates and 34 species of fish in a study conducted during 1987 and 1988. The USEPA (1989) reports that over 250 species of birds have been seen in the Meadowlands, including waterfowl, raptors and song birds. Based on data collected and various ornithology studies over the years, more than 60 species of birds utilize the Meadowlands for nesting and breeding. The intertidal mudflats near Sawmill Creek are the feeding ground for over 40 species of shore birds, while 10 species of raptors have been observed to feed on the wet meadows, landfills and fields in the region. Waterfowl such as terns, skimmers and grebes are often observed in the District's marshes. This category also includes over 20 species of ducks including mallards, black ducks, pintails and canvasbacks. These waterfowl, along with the long-legged wading birds such as herons and terns, utilize the District habitats for refuge, resting, feeding and nesting.

Common to the Meadowlands are the short-eared owl and the northern harrier. Osprey have also been observed in the District. Shorebirds and wading birds including the snowy egret, bitterns, rails and the great blue heron make the Meadowlands their home. The impoundments are heavily used by wading and shore birds traveling the Atlantic Flyway and support the largest known breeding population of pied-billed grebes in New Jersey. Finally, the District is rich in its population of songbirds. They include the marsh wren, winged blackbird, warblers, thrushes, starlings, titmice, among others.

A variety of mammals have made the Meadowlands their home. The species commonly found in the freshwater wetlands and at higher elevations in the intertidal zone include opossum, shrews, mice, moles, raccoon, weasel, skunk, fox, chipmunk, squirrel, muskrat, rat, cottontail, and feral dogs and cats. Additionally, this habitat provides the muskrat with the necessary raw materials for the construction of its home. Freshwater marshes also provide the necessary habitat for leopard frogs; snapping, painted and spotted turtles; and many aquatic insects.

A listing of declining, endangered, and threatened wildlife sighted in the District is maintained by the New Jersey Division of Fish and Wildlife. These species are presented in Figure 5.7. A declining species has exhibited a continued decline in population numbers over the years. Endangered species are those whose survival prospects in the State are in immediate danger because of a loss or change in habitat, overexploitation, predation, competition, disease or contamination. Threatened species are those species that may become endangered if conditions begin to or continue to deteriorate.

The District also contains a Natural Heritage Priority Site, the Kearny Marsh. Natural Heritage Priority Sites represent some of the best remaining habitat for rare species in the State and exemplary natural communities.

## FIGURE 5.7
### Declining, Endangered, and Threatened Wildlife Observed in the Meadowlands District

| Common Name | Scientific Name | State Status |
|---|---|---|
| **Bird Species**: | | |
| American Bittern | *Botaurus lentiginosus* | E-3 |
| American Coot | *Fulicia americana* | D |
| Black Skimmer | *Rynchops niger* | E |
| Bobolink | *Dolichonyx oryzivorus* | T |
| Least Bittern | *Ixobrychus exilis* | D |
| Least Tern | *Sterna antillarum* | E |
| Northern Harrier | *Circus cyaneus* | E-3 |
| Osprey | *Pandion haliaetus* | T |
| Peregrine Falcon | *Falco pereginus* | E |
| Pied-Billed Grebe | *Podilymbus podiceps* | E-3 |
| Savannah Sparrow | *Passerculus sandwichensis* | T |
| Yellow-Crowned Night Heron | *Nyctanassa violaceus* | T |
| Grasshopper Sparrow | *Ammodramus savannarum* | T |
| Sedge Wren | *Cistothorus platensis* | E |
| **Reptiles:** | | |
| Wood Turtle | *Clemmys insculpta* | T |
| **Plant Species**: | | |
| Dog Fennel Thoroughwort | *Eupatorium capillifolium* | E |
| Cyperus-like-Sedge | *Carex pseudocyperus* | E |
| Canada hawkweed | *Hieracium kalmii* | E |
| Smooth rattle-snake root | *Prenanthes racemosa* | E |
| Salt Marsh Bullrush | *Scirpus maritimus* | E |
| Sea-side arrowgrass | *Triglochin maritimum* | E |
| Wafer-Ash | *Ptelea trifoliata* | E |

D=Declining; T=Threatened; E=Endangered; 3=Breeding population only

Note: Information provided by the Natural Heritage Program cannot provide a *definitive* statement on the presence, absence, or condition of biological elements in any part of New Jersey. Information supplied by the Natural Heritage Program summarizes existing data known to the program at the time of the request regarding the biological elements or locations in question.

*Sources: Draft Environmental Impact Statement for the Special Area Management Plan, June 1995; NJDEP Natural Heritage Program, January 2003*

***Wetlands and Estuaries***

Besides the Hackensack River, one of the predominant environmental features of the Meadowlands is its wetlands. The wetlands in the Meadowlands have a history of transition. Approximately 17,000 years ago, the last continental glacier began to retreat from New Jersey. The melting water became trapped behind the terminal moraine to form Glacial Lake Hackensack. The glacial lake existed for at least 2,000 to 3,000 years. The first postglacial wetland community in the area was dominated by black ash, followed by a mixture of black ash, tamarack, and black spruce.

Between 1100 and 1200 years ago, Atlantic white cedar moved into the area. Rising sea level, saltwater intrusion, and exploitation by European settlers led to the demise of the cedar. Freshwater and brackish water marsh grasses eventually replaced the cedar. Increasing sea level and salinity led to a more brackish and salt marsh community that exists in the Meadowlands today.

Recent changes in the Meadowlands have been more abrupt and drastic. The first cause of change was the attempt to "reclaim" the Meadowlands as arable land. Beginning in the 1920's, so-called reclamation activities were pursued to control mosquito breeding. The diking and ditching undertaken to drain the Meadowlands probably aided in the decline of the cedar bogs. Additional human interventions leading to the decline of the cedar in the Meadowlands may have been the harvesting for use in ship building, to make plank roads to traverse the Meadowlands, and for lumber and shingles. Some of the cedar swamps were also burned to drive out pirates.

The second major cause of change in the Meadowlands environment was the construction of the Oradell Dam, completed in 1922. This dam limited fresh water inputs into the lower Hackensack River and increased the tidal effects, moving the head of the tide upstream. As the population served by the Oradell Reservoir increased, fresh water flows over the dam decreased, resulting in a more saline environment for most of the District.

Another major historic event relates to both the dikes that were built to "reclaim" the wetlands and the construction of the Oradell Dam. Because the dikes isolated large expanses of land from tidal waters, the layers of peat that existed at the bottom of the marshes began to dry out and subside. Common reed (*Phragmites australis)* began to colonize these drier, less saline areas. The land behind the dikes sank to lower elevations than the water level in the Hackensack River. In 1950, a major hurricane breached most of the dikes, and the saline waters of the Hackensack flooded large expanses of the Meadowlands. In some areas (e.g. the Sawmill Creek Wildlife Management Area) the *Phragmites* were unable to survive in the deeper, more saline waters, and large expanses died off. Only recently, the resulting mudflats are being slowly revegetated by salt-marsh cordgrass (*Spartina alterniflora)*.

In addition to draining the marshes, some of the estuary was filled to provide land for residential and industrial development. In 1897 there were 18,580 acres of tidal marshes and 1,465 acres of freshwater meadows in the Meadowlands region including land outside the District. As a result of draining and filling marshes, only about 8,400 acres of the original wetlands and

aquatic habitats in the lower Hackensack River Basin remain in the District today. The remaining estuary includes vegetated marshes, open water and mudflats.

In an effort to identify and locate the wetlands in the Meadowlands District, an advanced identification (AVID) study of the entire Meadowlands District was begun in the late 1980's. The intent was to identify and characterize how well the wetlands were performing. This study confirmed that approximately 8,400 acres of wetlands and waterways are present in the Meadowlands District and occur in all of the 14 constituent municipalities. The majority of the wetlands present in the Meadowlands District are estuarine and influenced by the tide. The largest concentration of estuarine wetlands is located in Carlstadt and Lyndhurst. Freshwater wetlands also exist within the District, with the largest area known as the Kearny Marsh and the Penhorn Creek Basin.

Wetland professionals, environmental interest groups and government agencies have recognized the wetlands in the District as an important natural resource. The United States Fish and Wildlife Service (USFWS), as part of the North American Waterfowl Management Plan's Atlantic Coast Joint Venture, has designated the Meadowlands as part of a "key priority habitat range" for migratory waterfowl traveling the Atlantic flyway. While the designation of "key priority habitat range" is not a regulatory status, the purpose of the USFWS designation is to emphasize to other agencies, planners and the general public that such areas are within the range of habitat that are important to migratory waterfowl. The US Environmental Protection Agency (USEPA) Region II has included the Meadowlands on its list of priority wetlands in New Jersey. Again, this list has no regulatory effect, but does identify areas that various federal environmental agencies believe are important resources within Region II.

***Terrestrial Ecosystems***

Little undeveloped open space remains in the Meadowlands District that is not wetland, an aquatic habitat or a filled and contaminated upland. The terrestrial habitats that do remain have been significantly modified since the arrival of the first settlers, first for farming and later for residential and industrial development. The major terrestrial open spaces that have become re-established in the District are on inactive solid waste disposal areas. Most of these inactive waste disposal areas have become revegetated and provide habitat for numerous species.

The plant communities on inactive landfills can be characterized as early to middle successional areas. The fills were abandoned only within the last twenty years. Dominant species are herbaceous plants, forbs (herbs other than grass) and small shrubs. The climax local forests have not yet had time to become re-established, a process that could take 200 years. As a result, these areas remain open, and terrestrial animals that dominate are those most closely associated with the traditional "old field" community of the Atlantic seaboard. This community is an association of plants and animals that develops in agricultural areas left undisturbed for several years. Both the plant and animal species in these open areas are considered opportunistic in that they can reproduce quickly and in large numbers to colonize disturbed areas. The populations, however, are continually changing as these opportunistic species are displaced by those of later successional stages, assuming no further human disturbances.

At the bottom of the food web in this transitional community are small mammals, birds, insect herbivores and grainivores (mice, moles, rabbits, crickets, grasshoppers, finches and sparrows). Mammal carnivores include foxes, weasels, and feral dogs and cats, while the bird carnivores are represented by raptors and owls. Though they typically nest in more forested suburban areas, omnivores that use the open spaces include squirrels, chipmunks, skunks and raccoons. The large mammal herbivores and carnivores often found in the transitional community (deer, coyote, etc.) are generally absent because of the relatively small size of the open spaces and the limited open corridors to the area from forested areas outside the District.

The open spaces provided by unused landfills are a very important habitat for the local and migratory populations of birds of prey which are not affected by the isolation from other terrestrial open spaces. The proximity of the unused fills to the wetlands increases the importance of these open spaces to raptors, because it increases the diversity of available prey. The peregrine falcon regularly feeds in the Meadowlands region. The red-tail hawk and the rough legged hawk are known to winter in the area. A pair of northern harriers has been confirmed to nest at Berry's Creek Marsh. Wintering short-eared owls use marshes and areas around landfills for hunting.

***Remnant and Unique Habitats***

Remnant habitats are those which were more common in the past but which have since dwindled to remnants of their former range. Unique habitats are those which have developed under unusual circumstances and now provide valuable habitat. Remnant and unique habitats provide a local diversity of plants and animals which may supply the stock to recolonize other areas of the Meadowlands at some future time. The USEPA has identified four types of remnant and unique habitats in the District:

Forested Wetlands - sites found near Teterboro Airport and Losen Slote Creek

Freshwater Meadows - sites located near Losen Slote Creek, Moonachie Creek, Kingsland Marsh and Kearny Marsh

Hardwood Forest - site at the rock outcroppings of Laurel Hill in Secaucus

High Salt Marsh - sites found near the Hackensack River in two locations: adjacent to the Hackensack River in Lyndhurst and in Secaucus

## Air Quality

The Meadowlands District is located in the heart of a regional transportation network and contains a range of industrial activities that affect air quality. Unclosed landfills emit methane. The District's air quality is also affected by other States. Since the original Clean Air Act of 1970, significant improvements in air quality have been achieved in the District.

The Clean Air Act Amendments established National Ambient Air Quality Standards (NAAQS) for six pollutants, all of which are monitored by the New Jersey Department of Environmental Protection (NJDEP) as part of the maintenance and reporting requirements of the State Implementation Plan (SIP). The criteria air pollutants are carbon monoxide (CO), sulfur dioxide ($SO_2$), total suspended particulates (TSP), nitrogen dioxide ($NO_2$), ozone ($O_3$) and lead (Pb). The NAAQS have been established for the purpose of protecting the public health and welfare; they are divided into primary and secondary standards. The primary standards are intended to protect public health with an ample margin of safety. Secondary standards are intended to protect public welfare from known or anticipated adverse effects of a pollutant. The USEPA and the NJDEP monitor air quality to determine area compliance with the NAAQS. Areas where air pollution persistently exceed the standards may be designated as nonattainment areas by the USEPA.

The Meadowlands region is impacted by both mobile and stationary sources of pollution. Mobile sources can move from place to place and consist of such sources as cars, trucks, buses and trains. These sources contribute a significant amount of pollution to the region. Stationary sources of pollution are fixed and include point sources and area sources. Point sources are stationary facilities or processes that emit significant air pollution during manufacturing, power generation, heating, incineration, or similar activity. In general, these are located at industrial sites and power generating facilities. Area sources are small sources of pollution that may account for a sizable amount of air pollution when their emissions are added together. Examples include consumer products such as personal care products, residential heating and fuel use, gasoline stations, dry cleaners, bakeries, and metal recycling.

The District is located in the New York-Northern New Jersey-Long Island, NY-NJ-CT nonattainment area for persistently failing to meet the national ambient air quality standards for ozone and carbon monoxide:

- Ozone is the major component of smog. It is formed through chemical reactions in the atmosphere. Compounds such as volatile organic compounds (VOC's) and oxides of nitrogen (NOx) react to form ozone in the presence of sunlight. Sources of VOC's include automobiles, chemical manufacturing facilities, drycleaners, paint shops, and other commercial and residential sources that use solvent and paint. NOx forms when fuels are burned at high temperatures. The two major sources of NOx are transportation vehicles and stationary combustion sources, including electric utility and industrial boilers. More measures need to be taken to meet health standards regarding ozone in the future.

- Although the region is in non-attainment for carbon monoxide, levels have declined significantly in recent years. Nationwide, transportation sources account for 77 percent of carbon monoxide emissions, the largest single contributor being highway motor vehicles.

The District and its surrounding environs have been classified as attainment for the remaining four NAAQS: sulfur dioxide, total suspended particulates, nitrogen dioxide, and lead. New Jersey's State Implementation Plan (SIP) calls for annual incremental reductions in ozone and carbon dioxide emissions. The SIP contains four main components as follows:

1. Conformance with NAAQS.
2. Control strategies for both mobile and stationary sources of pollution.
3. Reasonable Further Progress Report, which describes improvements to date, and necessary future steps needed to maintain and/or establish attainment.
4. Transportation control measures through which commitments are made for transportation planning such as ride sharing, exclusive bus lanes, and intermodal park and ride facilities.

The Transportation Improvement Plan (TIP) was created to provide a defined list of proposed improvements scheduled for implementation within a state program period. Internal programs have been prioritized based on the Regional Transportation Plan (RTP). This has fulfilled the federal requirements for metropolitan planning transportation organizations to coordinate among agencies; to monitor the performance of transportation systems; to prepare and maintain capital improvement plans; and to develop and annually update a multi-year program of projects to be implemented with available funds.

## Open Space

There have been several open space plans for the Meadowlands area, the first of which was adopted by the Commission in 1972. The second plan was written in 1984 as an update, but was not formally adopted. In the spring of 1997, the Commission adopted an Open Space Plan as part of its review of existing policies and guidelines. These plans utilized the Hackensack River as the focal point through which wetlands and their diverse flora and fauna would be preserved while providing access to the river. They described the constraints, ecological considerations and techniques for implementing an open space plan in the Meadowlands. This section and the related strategies of Chapter 10 supercede any previous open space plans for the District.

***Waterways/Waterbody Areas***

The Meadowlands District open space system consists of a network of open land and water areas with the Hackensack River as its defining attribute. The Hackensack River separates the eastern and western portions of the District, but joins the landforms at its periphery. The waterways/waterbodies of the Meadowlands total approximately 1,870 acres and are controlled by the State of New Jersey. Waterways and wetlands are included in Map 7.

**FIGURE 5.8**
*Mehrhof Pond in Little Ferry offers watchable wildlife opportunities.*

**FIGURE 5.9**
*Losen Slote Creek Park, also in Little Ferry. In the summer of 1992, a small seating area was added as part of a woodland restoration project in a partnership between Little Ferry and the NJMC.*

**FIGURE 5.10**
*Twilight view of the wood pergola in the courtyard at the NJMC's DeKorte Park in Lyndhurst.*

The Hackensack is fundamental to the entire District, because it provides for commercial uses, recreational uses, and wetlands preservation. The river gives hydrologic support to the adjoining wetlands. Tidal fluctuations and seasonal water events permit flooding of adjacent wetland areas, enhancing their quality. Also, the river presents the opportunity for observation, recreation, educational and scientific activities relating to the environment and the quality of the river. The District Zoning Regulations provide for a wetland buffer between waterways in the District and any proposed development. These buffers serve a biological function and insure proper drainage.

***Wetland Conservation Areas***

In addition to providing critical habitat for over 900 species of plants and animals, the District's wetlands impact human communities by serving as natural systems to purify water and alleviate the effects of flooding. Wetlands also improve our quality of life by providing a wide variety of recreational and educational opportunities. The NJMC strives to create an ecological balance between open space areas and development. It also seeks to improve the water quality of the Hackensack River estuary, including protection of the region from water pollution.

The primary tools for accomplishing these purposes are the preservation and enhancement of wetlands in the District. Wetlands preservation is the maintenance of a site in an unaltered condition. Wetland enhancement can be defined as any activity that restores a wetland degraded by human or other activity to a healthy functioning ecosystem.

Recognizing the urgent need to protect and restore our nation's wetlands, the NJMC initiated a comprehensive wetlands enhancement program in 1996. Enhancement activities restore wetland functions to areas that have lost their ability to provide quality fisheries, wildlife habitat and water quality purification. An inventory of the District's wetlands enhancement sites appears as Figure 5.11. To date, the NJMC has acquired approximately 1,800 acres of wetlands. The Commission continues to pursue the acquisition of suitable sites for this purpose as they become available.

As an additional wetlands activity, the NJDEP Bureau of Tidelands has granted the NJMC the management rights for approximately 1,600 acres of tidal wetlands in Lyndhurst, North Arlington, and Kearny. Due to the strategic location of the NJMC headquarters and the expertise of the Commission staff, the NJDEP deemed the NJMC as the ideal entity to manage these properties and provide regional park planning functions. The largest parcel in this endeavor is the state-owned Sawmill Creek Wildlife Management Area. The 788-acre site, located in the towns of Lyndhurst and Kearny, is dedicated as a wildlife management area and serves as an excellent feeding habitat for local and migratory waterfowl. It functions as one of the best examples of a low salt marsh/mudflat habitat in the District.

## FIGURE 5.11 Wetland Enhancement Sites in the Meadowlands District

| Enhancement Site | Location | Size (Acres) | Design Plan | Project Status |
|---|---|---|---|---|
| **Skeetkill Creek Marsh** | Ridgefield | 16.3 | Enhancement of the wetlands to include the creation of open water areas, low/high marsh zones and upland islands for foraging, resting and nesting habitats. Public access features include a small barrier free park with seating areas, bird blind for wildlife viewing and interpretative signage. | Enhancement activities were completed in December 1998. This site is open to the public. |
| **Secaucus High School**** | Secaucus | 38 | Current concept design involves enhancing wetland functions by controlling common reed, improving tidal flow, creating open water impoundments and incorporating flood control and outdoor classroom features. | Completed baseline studies. Conducting additional studies to develop restoration design for implementation under at Continuing Authorities Program (CAP). |
| **Mill Creek Marsh**+** | Secaucus | 203 | Hartz Mountain Industries enhanced approx. 70 acres of this site in 1980's. Enhancement of the remaining degraded wetlands included the re-establishment of tidal flow across the site with the creation of open water impoundments and grading of the marsh surface to support the development of low marsh, high marsh and upland habitat areas. This enhancement has resulted in low marsh habitats that are flushed daily by the tides, lowland scrub-shrub passerine habitats along the marsh/upland ecotone and creation of breeding, wintering and migratory habitats. A secondary component is the passive park and ~ 1.5 mile walking trail. Approx. 3 miles of canoeable channels with access from Mill Creek were created as a result of this project. | Construction activities were completed in 1999 with major park development activities completed in summer 2002. The site is subject to continuing ecological monitoring and maintenance activities. The site was open to the public in October 2002. |
| **Riverbend Wetland Preserve** | Secaucus | 58 | Wetland Preservation | Site has been identified as a Tier 1 Restoration Site in the Hackensack DPMP. |
| **Anderson Creek Marsh**** | Secaucus | 53.2 | Conceptual design plan to control *Phragmites australis* by re-establishing tidal flow with the expectation of increasing habitat diversity. | Project on hold pending funding allocation. |

| | | | | |
|---|---|---|---|---|
| **Eastern Brackish Marsh+** | North Bergen | 75.24 | Wetland enhancement project implemented by Hartz Mountain Industries in the 1980s. Project resulted in increased habitat diversity by re-establishing tidal flow and creating low marsh and upland habitats. | Access to the public via boat/canoe. No trails. |
| **Oritani Marsh*** | East Rutherford | 224.8 | Wetland preservation and enhancement activities. | Completed baseline studies in 2000. Site has been identified as a Tier 1 Restoration Site in the Hackensack Project Management Plan. |
| **Lyndhurst Riverside Marsh Preserve*** | Lyndhurst | 31 | C&F Realty enhanced approx. 9 acres of wetlands on this site in 1994. Enhancement of the remaining acres will include the re-establishment of tidal flow and an increase in habitat diversity. | Activities are on hold pending the allocation of funding. |
| **Harrier Meadows*** | North Arlington | 77.5 | Wetland enhancement included the excavation of 20 acres of shallow impoundments, which are hydrologically connected to the surrounding Kinglands mudflat to provide tidal flow. The impoundments are used to control common reed and purple loosestrife. Spoils from the excavation were used to create suitable nesting, resting habitats. The upland improvement part the project included the creation of a scrub-shrub border along the base of the 1.25 mile Meadows Path extension on the site's western and southern boundaries and around the margins of the impounded areas. Additional public access features include benches, wildlife viewing blinds and interpretative signage. | Site is open to the public for guided tours. Contact the Meadowlands Environment Center. |
| **Kearny Freshwater Marsh*** | Kearny | 236 | The Kearny Marsh is among the wetlands with the greatest ecological significance within the Meadowlands District. Studies are needed to determine the best approach to preserving and enhancing this valued resource. | Site is open to the Public for guided tours through the Meadowlands Environment Center. Site has been identified as a Tier 1 Restoration Site in the Hackensack Project Management Plan. |
| **Kearny Brackish Marsh** | Kearny | 115.5 | Currently no enhancement plan for this site. | |

* Included in Meadows Path
** Included in Secaucus Greenway Plans
\+ Included in Blue Water Trail Plan

***Landfill restoration/management areas***

Existing and former landfills in the District total approximately 1,300 acres. Most landfills in the District are now inactive. In order to mitigate the environmental impacts from these sites, they must be capped, contained with a cut-off wall and leachate collection system and a landfill gas recovery system. These activities are known as “closure” measures. Post-closure involves the maintenance of all aspects of the landfill closure improvements for a minimum of 30 years following closure of a site. Some of these landfills are proposed for recreational/commercial use in conjunction with passive open space use. Many are potential brownfield development sites.

The District landfills are unique since most were begun prior to the 1960s, and many involved filling of wetlands. In general these operations entailed excavation of the marsh soils and backfilling solid waste into the wetlands. Little or no soil cover was applied, and no environmental precautions were incorporated into the design. This was at a time when landfill owners and operators could walk away from garbage dumps without making any environmental improvements. The result was what the Commission refers to as "orphan" landfills, since there is no money reserved for their closure. Rain filtering uncontrollably through decomposing garbage turns into leachate, a tea-colored liquid that seeps into rivers and streams. This generates landfill gas, consisting of a roughly 50/50 mix of methane gas and carbon dioxide. The gas vents through the surface of the landfill. Under certain conditions, methane gas can cause fires or explosions. Prior to many of the controls now in place, drivers on the northern portion of the NJ Turnpike were often greeted by wafts of black smoke coming off the "meadows."

The Commission has taken over the liability and initiated closure of almost 500 acres of landfills in the District. In addition, another 100-acre site has been closed by the Bergen County Utilities Authority adjacent to the NJMC’s office complex. This landfill was purchased by the NJMC in June 2002. Recently, through Commission efforts, the NJDEP has begun the process of geotechnical investigations and the preparation of plans for the closure of the 1-D landfill in Kearny that leaches tens of thousands of gallons daily into the surrounding wetlands. This site currently has a landfill gas recovery system.

The Commission has been able to remediate these sites through the construction of perimeter cutoff walls that extend to the naturally occurring clay layer beneath the landfills. This clay layer meets or exceeds the liner standards established by the State for vertical permeability, or the ability of water to pass through the soil. The cutoff wall design utilizes a vertical trench that extends into the underlying clay layer, creating a “bathtub.” The trench remains stable during construction by pumping a “slurry” mixture of water, soil and bentonite clay. This clay is mined specifically for its ability to swell when wet and seal openings in the excavation. Once stabilized, this effectively isolates the landfills hydraulically from the surrounding wetlands.

Once this vertical barrier is constructed, a leachate collection system is constructed to maintain the leachate within the landfill at an established level. The Commission has designed the system so that the interior leachate level remains below the level of the wetlands surrounding the landfills. In the event that there is any migration of liquids through the cutoff wall, the liquid would tend to travel into the landfill, and not out to the wetlands. This state-of-the-art “inflow landfill” design has been used successfully throughout the District.

The installation of an impermeable cap on top of the landfill restricts the infiltration of precipitation, which decreases leachate production. Impermeable caps have been installed on top of the Commission 1-A Landfill and the Commission portion of the BCUA Kingsland landfill. The Commission has utilized a particular geomembrane (plastic) liner design as a cap that combines a woven geotextile bonded to both sides of the liner. This prevents soil from sliding off the liner as well as preventing punctures. These liners are then covered with topsoil, seeded and vegetated.

Among the other landfills in the District are the following:

- The Malanka/Mall landfill located in Secaucus is a 67-acre, privately-owned site, divided into two parcels by the NJ Transit Boonton rail line. Operation of the landfill ceased in 1983, but the site was not formally closed in accordance with State standards. Rip-rap has been placed at the river edge to prevent garbage from floating into the adjacent water. The site may have redevelopment potential due to its proximity to Secaucus Junction.

- The 1-D landfill in Kearny was operated by a private company under a lease arrangement with the Town of Kearny until 1982. The 83-acre landfill is known to be heavily contaminated with oil from a former waste oil facility on the adjacent property. The site was never formally closed in accordance with State standards. Although there are no leachate collection or water quality monitoring structures at present, a landfill gas recovery plant is located onsite. The landfill is expected to be dedicated as open space due to a variety of problems and site characteristics that would limit development, including height and composition of the landfill, known slope stability problems, and magnitude of remediation cost.

- The 1-A landfill, also located in Kearny, was formally closed by the Meadowlands Commission in 1985. The 50-acre site has leachate and gas collection systems in place, as well as a synthetic cap on top of the site.

***Parklands***

Parklands are open spaces consisting of any combination of 1) active recreational facilities, such as athletic fields, playgrounds, and running tracks; and 2) passive recreational facilities such as picnic areas, walking paths, wildlife viewing locations and sitting areas. These open spaces are established and maintained to serve human recreational needs and provide habitat. Park and recreational areas provide personal, social, economic and environmental benefits.

The NJMC's 1972 Open Space Plan called for a total of seven public areas representing a mere twenty-four acres. Today, with new parks and park additions in Little Ferry, Lyndhurst, and Secaucus, there are over 255 acres of park facilities in the Meadowlands District (The total includes only that portion of DeKorte Park accessible by the public.). The NJMC has provided technical and/or financial assistance for park facilities in the District including Richard W. DeKorte Park and the John Gagliardi Ballfields in Lyndhurst, Losen Slote Park in Little Ferry and Snipes Park and Hudson County Park at Laurel Hill in Secaucus. An inventory of parks in the District appears as Figure 5.12. Parklands and other open space attributes existing in the District are presented as part of Map 14, the Green Map.

## FIGURE 5.12
### Parks and Recreation Areas in the Meadowlands District

| Location/Name | # of Acres | Amenities |
|---|---|---|
| | | |
| **MUNICIPAL OWNERSHIP:** | | |
| **Little Ferry, Bergen Co. (2)** | **Sub-total 9.85** | |
| Birch Street Park | 1.01 | Open area |
| Losen Slote Park | 8.84 | Football, base/softball, soccer, hockey |
| **Lyndhurst, Bergen Co. (1)** | **Sub-total 35.37** | |
| Gagliardi Ball Field | 35.37 | Base/softball, soccer fields, track, restrooms, lighting |
| **Moonachie, Bergen Co. (1)** | **Sub-total .28** | |
| Concord Street Park | .28 | Playground/tot lot, picnic area |
| **Ridgefield, Bergen Co. (1)** | **Sub-total 3.0** | |
| Meadowlands Field | 3.0 | Base/softball field |
| **Secaucus, Hudson Co. (12)** | **Sub-total 67.82** | |
| Buchmuller Park | 5.42 | Little League, base/softball fields, basketball, tennis, ice rink, bocce courts, picnic area, handball, shuffle board, ADA compatible rest rooms and playground, kiddy shower |
| Duck Pond | 2.59 | Picnic area, ADA accessible decks |
| Eckle Park-9th Street Playground (Pocket Park) | .07 | Picnic area, basketball, ADA compatible playground |
| Ivanoski Park | .22 | Picnic area, ADA compatible playground, kiddy shower |
| Kane Stadium | 4.46 | Baseball, football fields, ADA compatible restrooms, nighttime lighting |
| Meadowlands Parkway Athletic Fields | 6.3 | Softball fields, nighttime lighting |
| Mill Creek Park (Pocket Park) | .41 | Buffer |
| Mill Ridge Field | 9.95 | Base/softball fields, nighttime lighting, soccer, chip & putt |
| Mill Creek Point | 7.0 | Planned: Marina, picnic area, canoe launch |
| Secaucus High School Athletic Field | 25.92 | Base/softball fields, tennis, basketball, running track, nature trail |
| Shetik Field | 3.4 | Soccer, basketball, street hockey |
| Smit Park | .11 | ADA compatible playground, picnic area |

**FIGURE 5.12**
**Parks and Recreation Areas in the Meadowlands District (Cont.)**

| Location/Name | # of Acres | Amenities |
|---|---|---|
| | | |
| **Secaucus, Hudson Co. (Cont.)** | | |
| Snipes Park | 8.86 | Passive recreation, picnic area |
| Trolley Park (Pocket Park) | .11 | Passive recreation, picnic area |
| | | |
| **COUNTY OWNERSHIP:** | | |
| Laurel Hill, Secaucus, Hudson Co. | 104.45 | Boat ramp, walking trails, gazebo, base/softball, soccer, football fields, nighttime lighting, Snake Hill (a 16-acre rock outcropping) |
| | | |
| **NJMC OWNERSHIP:** | | |
| DeKorte Park, Lyndhurst, Bergen Co. | 128.5 | Environmental Center, walking trails, gazebo |

In addition to the Parks in the District, there are several state facilities offering an array of recreational and educational opportunities. The Meadowlands Sports Complex is operated by the New Jersey Sports and Exposition Authority (NJSEA). Although the Meadowlands Sports Complex is outside the administrative jurisdiction of the NJMC, it is located within the physical boundaries of the Meadowlands District. The Sports Complex is the largest recreational facility within the District, serving the New York/New Jersey metropolitan region. The complex includes a racetrack, with both thoroughbred horse and harness racing, and Giants Stadium, home to two professional NFL football teams, the Giants and the Jets and one professional soccer team, the Metro Stars. The Continental Airlines Arena is home to the professional NBA basketball team, the Nets and the professional NHL hockey team, the Devils. In addition, the Complex hosts major athletic, cultural, music and other entertainment events.

The NJMC's administrative offices and environmental center are situated within the boundaries of Richard W. DeKorte Park. A major estuary along the Atlantic flyway, much of the site was originally an open, tidally influenced mud flat. Impacted by former landfill operations, the reclamation of the site and its evolution into a park involved habitat restoration and conservation. The Meadowlands Environment Center is centrally located along a water body within the Richard W. DeKorte Park and serves as a visitor center, education facility and information resource for ecological and scientific data.

Individual park elements within Richard W. DeKorte Park include:

**Kingsland Overlook** - Built in 1990, this park transformed six acres of the Bergen County Utilities Authority (BCUA) sanitary landfill into a series of native plant communities, illustrating the process of natural succession. Prior to the end use, landfill closure improvements included a leachate collection system, methane vents and an impervious synthetic cap, which was partially manufactured from recycled plastic soda bottles.

**Lyndhurst Nature Reserve** - This project involved the reclamation of a 3.5-acre, illegally filled area into wetland and upland habitats, educational facilities and other site amenities. The project also involved the restoration of a brackish wetland ecosystem along the island's edge and the establishment of an upland northeast woody plant community.

**Marsh Discovery Trail** - A boardwalk trail connects a series of dredge spoil islands within the Kingsland Impoundment. The trail traces the route of Kingsland Creek and provides access to rare wildlife habitats as well as providing educational and recreational opportunities for bird watchers and nature lovers.

**Transco Trail** - This trail involved the transformation of a natural gas pipeline service road into a self-guided nature trail. The public/private partnership project links the various open space components found within Richard W. DeKorte Park.

The trails within Richard W. DeKorte Park not only provide access to the various park elements, but also play a role in connecting other open space components within the District. All of the aforementioned trails represent portions of Meadows Path, a planned 25.5 mile District-wide trail system, linking nine of the fourteen constituent municipalities.

A listing of parks and recreation areas outside the Meadowlands District but located within one of the 14 municipalities comprising the District is included as Figure 5.13.

***Trails/Greenways***

Greenways provide continuous bands of open space by linking areas of development to natural areas. They offer unique experiences, combining recreational opportunities, alternative transportation routes and a connection to nature.

**Meadows Path** - In 1983, a master plan for a coastal, urban pedestrian trail system in the Meadowlands called Meadows Path was developed. The current version of this plan proposes a 25.5-mile pedestrian trail paralleling the western bank of the Hackensack River from Losen Slote Creek Park in Little Ferry to West Hudson Park in Kearny. When fully implemented, the trail will take advantage of existing trails, sidewalks, and utility company service roads to connect population centers and provide access to wildlife preservation areas, scenic river overlooks, marshes, woodlands, wildflower meadows, an environmental center, regional parks, boating facilities, ball fields, bus stops, and restaurants. Meadows Path will serve as a dedicated pedestrian artery through nine of the fourteen Meadowlands District municipalities.

To date, 5.35 miles of Meadows Path have been completed. These segments include a 0.5-mile woodland trail through Losen Slote Creek Park in Little Ferry; 2.25 miles of wheelchair-accessible trails through restored plant and animal communities within Richard W. DeKorte Park; a 1.5-mile pedestrian walkway along the Valley Brook Avenue Greenway, linking DeKorte Park and the Meadowlands Corporate Center in Lyndhurst; and the recently completed Saw Mill Creek Trail, a 1.1-mile pedestrian trail traversing

## FIGURE 5.13

**Out-of-District Park and Recreation Areas in Meadowlands Municipalities**

| Municipality | Owner | Name | Acres | Amenities |
|---|---|---|---|---|
| **Carlstadt** | Municipality | Lindberg Field/Park | 7.73 | Base/softball, roller hockey, playground/tot lot |
| | | Rasmus/Hagowski | 2.76 | Little League, soccer, handball |
| | | Staltz | 1.20 | Playground |
| | | Zimmerman | 2.06 | Open space |
| **E. Rutherford** | Municipality | Riggin Field | 14.00 | Multipurpose: football, base/softball, Little League, soccer, track, field house, restrooms |
| | | McKenzie Memorial Field | 4.00 | Multipurpose: base/softball, soccer, basketball, tennis playground/tot lot, restrooms |
| | | 10 parks less than 2 acres each | | |
| **Little Ferry** | Municipality | Indian Lake | 14.90 | Football, base/softball, Little League, soccer playground/tot lot, pond with dock, field house, meeting hall, restrooms |
| | | Willow Lake | 12.80 | Base/softball, soccer, playground/tot lot, field house, pavilion, shuffleboard |
| | | Memorial School | 8.20 | Baseball, softball |
| | | Washington School | 2.07 | Basketball, playground/ tot lot |
| | | 1 park less than 2 acres | | |
| **Lyndhurst** | Bergen County | Riverside County Park (also in N. Arlington) | 109.00 | Base/softball, soccer, basketball, tennis, ice skating, playground/tot lot, bocce, fitness trail, bike path, field house, meeting hall, restrooms, storage, pavilions |
| | Municipality | Town Hall Park | 5.62 | Handball, playground/tot lot, gazebo |
| | | Gallagher/Deloy | 4.20 | Little League, street hockey, field house, restrooms, concessions |
| | | 5 parks less than 2 acres each | | |
| **Moonachie** | Municipality | Redneck Avenue Park | 28.80 | Base/softball, Little League, field house, storage |
| | | W. Joseph Street Park | 3.10 | Basketball, tennis, street hockey, playground/tot lot, bike path, picnic area, senior center, gazebo |
| | | 1 park less than 2 acres | | |
| **N. Arlington** | Municipality | Skyline Sports Complex | 6.50 | Soccer, track, field house, restrooms |
| | | Allan | 2.80 | |
| | | Roosevelt Field | 2.00 | Soccer, basketball, playground/tot lot |
| | | 8 parks less than 2 acres each | | |

| FIGURE 5.13 (Cont.) Out-of-District Park and Recreation Areas in Meadowlands Municipalities | | | | |
|---|---|---|---|---|
| **Ridgefield** | Municipality | Veteran's Memorial Field | 17.00 | Base/softball, Little League, basketball, tennis, swimming pool, pool house, field house, restrooms, storage |
| | | Willis Park | 4.00 | Track, lighted football/soccer, locker rooms/bathrooms, basketball court, playground/tot lot |
| | | Marine Park | 2.00 | Playground/tot lot |
| **Rutherford** | Municipality | One Memorial | 39.92 | Football, base/softball, Little League, soccer, basketball, tennis, street hockey, playground/tot lot, bocce, fitness trail, track, jogging path, picnic area, field house, restrooms, storage, gazebo |
| | | Tamblyn Field | 7.12 | Football, base/softball, basketball, handball, tennis, playground/tot lot, picnic area, senior center, meeting hall, restrooms, storage |
| | | 8 parks less than 2 acres each | | |
| **S. Hackensack** | Municipality | Veterans | 3.78 | Base/softball, soccer, basketball, playground/tot lot, jogging path, gazebo |
| **Teterboro** | Municipality | 1 park less than 2 acres | | |
| **Jersey City** | State | Liberty State Park | 1122.00 | Liberty Science Center, Central Railroad of NJ terminal, walkway, marina, nature trails, fitness course, restaurant, playground, ferry service to Statue of Liberty/Ellis Island |
| | Hudson County | Lincoln Park | 273.00 | Restaurant, playgrounds, wading pool, softball, soccer, golf, track, football, tennis, basketball, picnic areas, restrooms |
| | | Washington Park | 21.00 | Pavilions, playground, wading pool, softball, soccer, basketball, tennis, passive, restrooms |
| | Municipality | Caven Point Recreational Facility | 17.29 | Base/softball, Little League, soccer, basketball, field house, restrooms, storage |
| | | Hackensack River Greenway | 34.00 | Passive |
| | | Pershing Field | 13.50 | Swimming pool/pool house, base/softball, tennis, ice rink, bocce, playground, track, passive |
| | | Bayside Park | 9.20 | Playground, softball, tennis, basketball, seating areas |
| | | Bright Street Gateway Recreational Facility | 6.30 | Little League, baseball, football, concessions, night lighting |
| | | Fiske/Riverview Park | 5.34 | Basketball, playground, spray shower, passive rec. |
| | | Leonard Gordon Park (Mosquito Park) | 5.34 | Basketball, tennis, playground, pavilion, passive rec. |

| | | | | |
|---|---|---|---|---|
| **Jersey City** (Continued) | Municipality | Hamilton Park | 5.29 | Basketball, tennis, playground, pavilion, passive rec. |
| | | Columbia Park (Greenville Memorial Park) | 4.68 | Passive recreation, swings |
| | | Enos Jones Park/Ed Franco Field | 4.58 | Field house, playground, softball |
| | | Lafayette Park | 4.20 | Pavilion, softball, basketball, playground, passive rec. |
| | | Arlington Park (William Thornton Park) | 3.40 | Pavilion, playground, passive |
| | | Audubon Park (Major John Desmond Park) | 2.77 | Basketball, tennis, playground |
| | | Pavonia/Marion Playground and Pool (Martucci Little League) | 2.67 | Swimming, pool/pool house, softball, basketball, bocce, passive recreation |
| | | McGovern Park (County Village Park) | 2.44 | Base/softball,basketball,tennis,picnic area,playground |
| | | Mary Benson Park | 2.30 | Softball, basketball, handball, restrooms, passive rec. |
| | | 39 parks less than 2 acres each | | |
| **Kearny** | Hudson County | West Hudson Park | 46.00 | Football, base/softball, Little League, soccer, tennis, playground/tot lot, jogging path, picnic area, spray pool, pond, senior center |
| | Municipality | Riverbank Park | 23.87 | Tennis, ice skating, playground/tot lot, picnic area, restrooms, pavilion |
| | | Gunnell Oval | 23.22 | Base/softball, Little League, soccer, basketball, playground/tot lot, restrooms |
| | | Veterans Memorial Field | 13.25 | Football, base/softball, Little League |
| | | Harvey Field | 8.44 | Base/softball, soccer, playground/tot lot, restrooms |
| | | Kearny High School | 3.00 | Football, track |
| | | Fairlawn Playground | 2.23 | Base/softball, basketball, playground/tot lot |
| | | Veterans Playground | 2.00 | Basketball, street hockey, bocce |
| | | 7 parks less than 2 acres each | | |
| **North Bergen** | Hudson County | N. Hudson Park | 167.32 | Base/softball, Little League, soccer, basketball, tennis, playground/tot lot, jogging path, picnic area, spray pool, pond. |
| | Municipality | 64th Street & Kilkenny Field | 9.80 | Football, base/softball, Little League, basketball, playground/tot lot, track, bike path, jogging path, field house, restrooms |
| | | 28th Street | 5.70 | Basketball, playground/tot lot |
| | | 10th Street | 5.70 | Basketball, playground/tot lot |
| | | 46th Street Park | 4.00 | Football, base/softball, soccer, basketball, playground/ tot lot, track, bike path, jogging path, picnic area, spray pool, restrooms |
| | | 4 parks less than 2 acres | | |
| **Secaucus** | Municipality | 2 parks less than 2 acres | | |

the Saw Mill Creek Wildlife Management Area that sits atop a dike originally built as a PSE&G service road for its Hudson Athenia electrical transmission towers. This seg–ment of the Meadows Path forms a critical link between Richard W. DeKorte Park and the future trails planned for the NJMC's 1E Landfill in Kearny.

**Secaucus Greenway** - The Secaucus Greenway is a planned, 15-mile waterfront green-way through Secaucus and Jersey City. Completion of this trail will allow public access along the river while providing a continuous pedestrian trail linking Secaucus retail, of-fice, commercial and residential districts. This trail will connect the Hudson County Park and the boat launch at Laurel Hill, Secaucus Junction, Snipes Park, Secaucus High School, the Mill Ridge Ball Fields, Mill Creek Point, Mill Creek Marsh, and Harmon Meadow Plaza north along West Side Avenue to 71st Street Park. The portions of the Greenway that are completed include trails in the Hudson County Park at Laurel Hill and a 1.5-mile pedestrian trail through a restored wetland within Mill Creek Marsh.

Mill Creek Point, a 7-acre site located on the banks of the Hackensack River, has been acquired by the Town of Secaucus to be reclaimed for open space and passive recrea-tional purposes. The NJMC, in partnership with the Town of Secaucus, is developing this site as a public waterfront park that will include a public canoe launch. Mill Creek Point will serve as the "gateway" to the Hackensack River, adjacent creeks and en-hanced wetlands in the Meadowlands District.

**Blue Water Trail** - The Blue Water Trail is a water-borne canoe trail including both named and unnamed waterways within the District. The main point of departure within the District is located at Mill Creek in Secaucus. When completed in spring 2004, the trail will enable canoeists to travel to any District park, enhanced wetland, or preserve accessible by water. These sites include the restored wetlands of Mill Creek Marsh, the Eastern Brackish Marsh and Cromakill Creek; parks such as Hudson County Park at Laurel Hill, Richard W. DeKorte Park and Snipes Park; and preserves like Anderson Marsh, Lyndhurst Riverside Marsh and the Saw Mill Creek Wildlife Management Area. A Blue Water Trail Map will be published and distributed by the NJMC to aid canoeists as they explore the District's waterways. Coordinating numerical markers will also be set at points along the water trail to serve as location identifiers.

***Marinas & Boat/Canoe Launch Facilities***

As the Hackensack River remains a focal point of the District, the Commission seeks to utilize the river as a rediscovered asset, particularly for educational and recreational purposes. There are several private boating facilities in the District located in the towns of Carlstadt, Little Ferry and Secaucus. Each of these commercial facilities offers varying amounts of boat storage, slips, repair facilities and public launch areas. The Hackensack River Public Boat Launch at the Hudson County Park at Laurel Hill is the District's sole public boat launch. This facility pro-vides seating areas, an information shelter, parking for tow vehicles and linkage to the County park's waterfront promenade. Marina facilities in the District are summarized in Figure 5.14.

## FIGURE 5.14
## Marinas and Boat/Canoe Launch Facilities in the Meadowlands District

| Location | Name of Facility | Marina | Boat/ Canoe Launch | Public | Private | Activity |
|---|---|---|---|---|---|---|
| Little Ferry | Riverside Boat Works | X | | | X | Slips, seasonal and live on, boat storage/repair, public boat ramp |
| | Little Ferry Marina | X | | | X | Slips, storage, repair |
| Carlstadt | Barge Club | X | | | X | Slips, restaurant, boat ramp |
| | Snipes | X | | | X | Slips, club house, storage, boat ramp |
| | Majestic Boat Club | X | | | X | Slips, club house, storage, boat ramp |
| | Waterfront Café/ Meadowlands Golf Center | X | | | X | Slips, restaurant, boat ramp |
| Secaucus | Coast Guard Auxiliary | X | | | X | Slips, private club |
| | Red Roof Inn | X | | | X | Slips, public boat ramp |
| | Harmon Cove | X | | | X | Slips for residences only |
| | Hudson County Park at Laurel Hill | | X | X | | |
| | Mill Creek Point | | X | X | | Canoe ramp only |
| | Extended Stay America Hotel | X | X | X | | Boat ramp, slips |

# KEY CONDITIONS

Although the NJMC has many successes in preserving and enhancing the natural environment of the District, the Meadowlands remains an ecologically fragile area.

- The District includes approximately 8,400 acres of wetlands and waterways. The NJMC holds title to approximately 1,800 acres. The Commission also has management rights without ownership to approximately 1,600 acres. The District's waterways total over 1,870 acres and are controlled by the State of New Jersey.
- Given its location in a major urban area, the Meadowlands offers extensive, critical wildlife habitats within its wetlands, waterways, and terrestrial ecosystems.
- The Hackensack River is a centerpiece of the District. The river system offers unrealized potential for recreation, open space and other uses. Flooding associated with the river system continues to be a problem in many developed areas.
- Tropical storms pose potential hazards.
- Although significant improvement has been made to regional water and air qualities in recent years, both resources still fail to meet all government standards.
- The District and the greater region contribute to and are a recipient of the consequences of climate change.

# SOURCES

Cheng, C. and E. Konsevick, "Trends in the water quality of an urban estuary: Hackensack Meadowlands, New Jersey," W.L. Lyke and T.J. Hoban (eds.) Proceedings of the Symposium on Coastal Water Resources, TPS-88-1, Wilmington, NC: American Water Resources Association, 1988.

Carswell, Louis D., US Geological Survey, prepared in cooperation with NJ Department of Environmental Protection, Division of Water Resources, Water Resources Investigations 76-74, June 1976.

City of Jersey City, Master Plan, 2000.

Clinton Bogert Associates, Bergen County Utilities Authority: Impact analysis of Sewage Treatment Plant Discharges on the Water Quality of the Lower Hackensack River, Final Report, 1990.

Cornell Agweb, Pragmites: Common Weed, <http://www.invasiveplants.net/phragmites>, 8 January 2003.

Hackensack Meadowlands Development Commission, Habitat Cover Map of the Hackensack Meadowlands, 1986.

Hackensack Meadowlands Development Commission, Environmental Operations Research Laboratory, Hackensack River Water Quality 1993-1996, 10 March 1997.

Kiviat, Erik and Kristi MacDonald, Hackensack Meadowlands, New Jersey, Biodiversity: A Review and Synthesis, prepared for the Meadowlands Partnership, 8 August 2002.

Konsevick, E., C. Hobble and P. Lupini, "Monitoring Effects of Urban Land Use on Estuarine Water Quality, Hackensack Meadowlands District, New Jersey," National Symposium on Water Quality, American Water Resources Association, November 1994, PP181-189.

Konsevick, E., C. Hobble and K. Barrett, "Monitoring the Effects of Drought on the Concentrations of Heavy Metals in the Hackensack River, New Jersey," American Water Resources Association, November 2002.

National Oceanic and Atmospheric Administration (NOAA), Hurricane Awareness, <http://www.nhc.noaa.gov/>

New Jersey Administrative Code, Chapter 9B, Surface Water Quality Standards; 19:4-4.14(a)6, 7, 8.

New Jersey Department of Environmental Protection, 2000 Air Quality Report, <http://www.state.nj.us/dep/airmon/00rpt.htm>

New Jersey Meadowlands Commission, Survey of District Recreation Facilities, 1999, updated 2001.

Town of Secaucus, Your Park and Recreation Guide.

US Army Corps of Engineers, Project Management Plan, Hackensack Meadowlands New Jersey Ecosystem Restoration Study, December 2002.

US Environmental Protection Agency, Final Report: Functional Assessment of Wetlands in New Jersey's Hackensack Meadowlands, prepared for USEPA Region II by the Maguire Group Inc., December 1989.

Vermeule, C. C., "Drainage of the Hackensack and Newark Tide Marshes," Annual Report of the State Geologist for the year 1896, Trenton, NJ: MacCrellish and Quigley, 1897.

Wacker, Peter O., Land and People: An Historical Geography of Pre-Industrial New Jersey, New Brunswick, NJ: Rutgers University Press, 1975.

Wolfe, Peter, The Geology and Landscapes of New Jersey, New York: Crane, Russack and Company, 1977.